wards made the property of the Society by the liberality of Mr. Poinsett.

The resolution of Mr. Peale was then adopted.

And the Society was adjourned.

Stated Meeting, April 1, 1864.

Present, nineteen members.

Dr. Wood, President, in the Chair.

A letter of acknowledgment was received from the Liverpool Literary and Philosophical Society, dated February 29, 1864.

Letters of envoi were received from M. the Minister of Public Instruction, dated Paris, November 21st, M. Hector Bossange, dated Paris, February 25, and the Liverpool Literary and Philosophical Society, dated March 17, 1864.

Donations for the Library were announced from M. Troyon of Lausanne, the London Reader, the Literary and Philosophical Societies of Liverpool and of Quebec, Silliman's Journal, the Academy of Natural Sciences, Professor J. C. Cresson, and Dr. Kirkbride of Philadelphia.

The death of Dr. Franklin Bache, at his residence in Spruce Street, on Saturday evening, the 19th ultimo, aged 71 years, was announced by Mr. Fraley, with a feeling tribute to his venerated character and long and varied relations to the Society. On motion of Mr. Fraley, the President, Dr. Wood, was requested to prepare an obituary notice, to be read before the Society.

Mr. Chase continued his remarks upon heat and afterwards illustrated the polarizing action of muscular energy by a magnetic needle held in the hand, but explained the phenomenon as due chiefly, if not solely, to a law governing the mechanical propagation of vibrations.

On account of the mutual dependence of all the forces of nature, and the reasonableness of Prof. Faraday's conjecture, that they are often, if not always, convertible more or less into each other,* it seems probable that the disturbances of the magnetic needle may be as closely connected with the earth's rotation, and the continually changing position of each point relatively to the sun, as those of the barometer and thermometer. Ampère held that the earth is an electro-magnet, magnetized by an electric current from east to west, the current being excited by the action of the sun's heat successively on different parts of the earth's surface as it revolves toward the east. The friction of trade-winds and ocean-currents and the variations of light and temperature that are produced by rotation and orbital revolution, must exert an influence upon the magnetic needle, and beside these indirect effects, M. Arago showed that simple rotation, in some unknown way, produces magnetism in bodies of every description. Many have supposed that this magnetism is derived from the earth by induction, but on account of the impossibility of escaping from the influence of terrestrial magnetism, it is difficult to obtain any conclusive evidence on the subject.† A similar impossibility has interfered with Prof. Faraday's endeavors to connect gravity and magnetic or electric action by experimental results. The probability of such a connection has been shown by the electricity developed in the dry pile of De Luc, and by Gen. Sabine's observation, that when the sun and moon were on the meridian the magnetic variation reached 5°, but when they were in quadrature, it fell as low as 20′.‡

The great forces of nature can be measured only by their disturbances or their deviations from uniformity. The action of gravity is so nearly uniform at all times and in all parts of the globe, that it is difficult to imagine any crucial experiment that could demonstrate its relations to magnetism. Perhaps a needle, hinged at its point of support, with the two extremities nicely balanced, might help us towards such a demonstration, if careful experiments were tried, to show the relative influence of gravity upon each extremity, both before and after magnetizing, and when subjected to artificial magnetism, so as to produce various amounts of deviation from the normal dip and declination. Or, centrifugal force, so applied as alternately to assist and oppose the effects of gravity, as in large fly-wheels revolving with various degrees of rapidity, may indicate variations of

* Phil. Mag. 4th Ser. 1, 68.

† See correspondence of M. J. Nickles, Silliman's Journal, v. 17, p. 117, &c.

‡ Silliman's Journal, vol. 19, p. 424.

magnetic influence, that can be explained only by the conversion of gravity into magnetism or the reverse.

Prof. Faraday, in a lecture before the Royal Institution in the year 1857, endeavored to show that our usual conception of gravity is not in harmony with the principle of "conservation of force." Prof. Brücke* and others, have tried to remove the difficulties in which the question is involved, but I believe none of the proposed solutions have been satisfactory to the learned philosopher who first started the discussion.

It has even been questioned whether gravity can be properly called a force, or whether it is anything more than a simple "tendency." Prof. Brücke has shown conclusively, that it is subject, like heat and other recognized forces, to all the laws which regulate the interchange of *actual* and *potential* energy; and our barometrical investigations furnish a beautiful illustration of the manner in which its tension is balanced by opposing forces.

We speak, indeed, of weight, as if it could be predicated only of bodies at rest, and as if it were so entirely distinct from momentum that no comparison could be properly instituted between the two. Precisely the reverse is true. Absolute rest is apparently an impossible condition of matter, for, to whatever extent the action of opposing forces may be relatively neutralized, the inconceivable rapidity of æthereal, planetary, and stellar motions, produces a constant change of place. Even if we confine our attention to the earth alone, in each instant (dt), every particle has a tangential motion (tan. $d\theta$), and a central motion of gravity (sin. $d^2\theta$) that constitutes a *vis viva* which we call its weight, and which is in equilibrium with the elasticity of the molecular æther. The sum of all the instantaneous energies is the same, whether the particle fall freely for any given time, or remain apparently at rest. All the potential energy which is transformed in one case into the actual energy of motion,† in the

* Phil. Mag., 4 S., 15, 81.

† The potential energy of gravity is represented by $g = 32$ ft. per second. The earth's rotation allowing only about $\frac{1}{290}$ of this amount, or .1107 ft. per second, to be converted into actual energy, the remainder must be employed in overcoming molecular elasticity. The formula $a = \left(\frac{gt^2r^2}{4\pi^2}\right)^{\frac{1}{3}}$ gives 26,221 miles as the radius of the sphere of attraction that is in equilibrium with the molecular elasticity at the earth's surface. These opposing forces must produce constant oscillations, and by the study of these oscillations, it may perhaps be possible to reconcile the several hypotheses of Newton, Faraday, Mossotti, and Challis, respecting the nature of gravitation. See Phil. Mag., 4 S., v. 13, p. 231-7, and v. 18, p. 447, sqq.

other is counteracted by an equivalent and opposite central energy of elasticity. Therefore, when we compare the relative effects of rotation and gravity, it is immaterial whether we use as the measure of force, the integral of the *vires vivae*, or the respective amounts of motion that the two forces would produce, if they were able to act freely for the same time. The difficulty of determining the repulsion of molecular elasticity precluding any satisfactory use of the former measure, I employed the other, and the precise accordance of the results thus obtained, with the results of observation, justified the correctness of the hypothesis, in the same manner as the accurate computation of planetary motions has confirmed the Newtonian theory of gravity.

Gravity, therefore, with the same propriety as heat, may be considered as a "mode of motion," whether acting merely as "dead weight," or as an accelerating or a deflecting force. If it can be shown that magnetism also originates in motion, we may be able to demonstrate the mutual convertibility that Faraday suspected.

The earliest hypothesis with regard to terrestrial magnetism looked for its cause to a powerful magnet, lying nearly in the line of the earth's axis. Subsequent discoveries led to a modification of this view by the supposition of another magnet, pointing towards the Siberian pole. Mr. Barlow's idea, that the magnetism is superficial and induced,* has now been generally adopted, and if it could be shown that solar or rotary action is capable of developing magnetism in particles such as those which are known to constitute our globe, the great difficulty in the way of a satisfactory explanation would be removed.† Ampère's, Barlow's, and Christie's experiments showed that simple rotation is sufficient to affect the magnetism of a compass-needle,‡ and in the oxygen of the atmosphere, which, as Faraday discovered, has a specific magnetism, variously estimated at from $\frac{1}{88}$§ to $\frac{1}{287}$‖ of that of iron, we have a medium through which any induced magnetism may be distributed over the entire surface of the earth. Some simple experiments that can be easily repeated, seem to confirm Ampère's views, and to indicate the manner in which the circulating electric current is excited.

* Phil. Trans., 1831.

† Enc. Brit., Art. "Magnetism."

‡ The effect of rotation on the magnetic needle may be shown in a rough way, by causing an ordinary grindstone to revolve rapidly, and bringing a compass near its edge.

§ By M. Becquerel. ‖ M. Plücker.

There is a species of mechanical polarity, of which I have never seen any notice, that is apparently produced by motions resembling those to which the air is continually subjected. It may be exhibited in the following ways:

1. In the middle of a basin of water, lay a long strip of any substance (floating it by corks or otherwise, if it is heavier than water). After the water has become still, lift the basin carefully by one hand, and hold it at arm's length. The intermitting muscular action produces longitudinal vibrations, which tend to bring the floating strip into a line with the outstretched arm, and the tendency may be increased by moving the basin gently up and down.

2. Hold the gimbals of a binnacle compass so that it can swing only in one direction, and cause it to move like a pendulum in that direction. The needle will tend towards the line of oscillation. Vessels may have been lost from ignorance of this fact, for it is not unusual for compass pivots to become so worn that the needle moves sluggishly, and in order to start it, the compass-box is shaken. If one of the gimbal hinges should be rusty, the shaking would bring the needle into a line perpendicular to the axis of the free gimbal, and the captain might easily suppose that he was sailing north, when his course was due east or west.

3. Take an ordinary pocket compass, grasp it firmly between the thumb and finger of one hand, and move it quickly up and down through a small arc. The needle, as in the last instance, will tend towards the plane of motion. This experiment may be variously modified, according to the length and directive energy of the needle, the steadiness of the operator's nerves, &c. Sometimes a simple grasp, with a powerful muscular contraction, will bring the needle into line, without any other vibration than that which arises from the irresistible nervous tremor. Sometimes the momentum acquired by each pole in its approach to the operator, carries it forward so as to bring the other pole under the wave-influence, and the needle is thus made to rotate so rapidly as to become nearly invisible.

The polarity in each of the three cases here enumerated, is easily explained upon purely mechanical principles, but there are some indications that seem to show a close connection between the mechanical vibrations and those of nervous electricity. There appears to be a great difference in the control of different individuals over the needle. Some can bring it into line at once, with scarcely any perceptible motion, while others are obliged to use considerable effort; the needle does not seem at all times equally susceptible; it often

appears more easy to produce rotation in one direction, than in the other. There may, therefore, be a natural connection between these experiments and those of M. Du Bois Raymond, who attached two strips of platinum to a very delicate galvanometer, and caused them to dip into two cups of salt water. Dipping the fingers of each hand into the cups, and alternately bracing the muscles of each arm, he produced a perceptible deflection of the needle. MM. Becquerel and Despretz repeated the experiment without obtaining very satisfactory results, but M. Humboldt was more successful.* Add to these phenomena the well-known evidences of a constant current, circulating around magnets, and if we suppose that electricity consists simply of vibrations, it will seem perfectly natural that the magnet should obey the strongest vibrations.

Mr. Briggs exhibited a suite of specimens, to illustrate the steps of the new process by which non-resinous woods are converted into paper pulp, by the application of soda at high temperatures.

Dr. Emerson embraced the opportunity to describe the successful performance of the new machines, now employed in cleaning out flax fibre for market, with little or no loss in the form of tow, the flax, thus obtained, commanding a market value three or four fold that of the seed; so that it has been stated that a profit of $400 per acre of flax-sown ground has been realized. The machine has three sizes and forms, and may be called the cotton gin of the North. Mr. Briggs explained how much of the superiority of the Irish linen depended on the perfection of the rotting process carried forward under the regular humid climate of Ireland, and considered it improbable that any successful competition could be made in America, until some artificial chemical process shall be discovered applicable to the case, like the hot soda process, which he had described in connection with wood fibre, and by which fine cotton-like flax had also been produced, a specimen of which he exhibited.

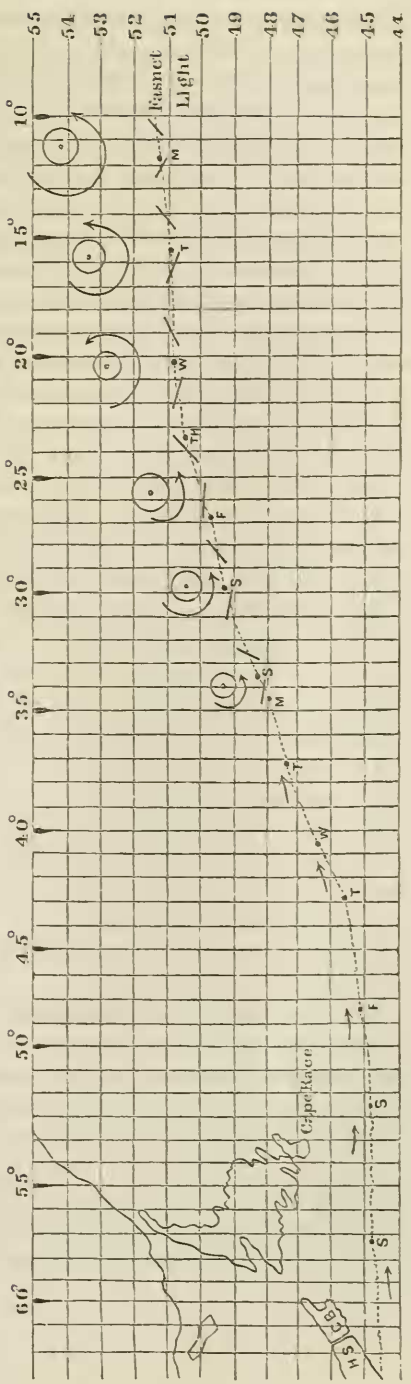
Mr. Lesley described the succession of gales encountered by the B. M. S. S. Canada, on her hundredth and longest voyage, from Liverpool to Boston, between the 11th and 21st of January, 1864.

* See Silliman's Journal, vol. 8.

The steamer left Liverpool, with fair weather, on the 9th, and encountered a smart blow in the Irish Channel, but ran along the Irish coast in fair weather, touched at Queenstown for the mails, and passed Fasnet Rock Light in the night of Sunday, January 10th. It began to blow from the westward here, and continued to blow from that quarter, dead ahead, with variable violence, until Thursday night, January 21st. The steamer reached Halifax, in the face of light west winds, Monday evening, January 25th, and Boston, Wednesday afternoon, January 27th, after a voyage of *nineteen* days.

The accompanying woodcut shows the course of the steamer and her position each noon between Fasnet Light and Halifax. In the first eight days, that is to say, from Sunday noon to the second following Monday noon, the Canada encountered six distinct gales, the sixth and last raging through Sunday night with such violence that the steamer could barely be kept to the wind; and the officers asserted that no sailing vessel could have lived.

At the beginning of each gale, the wind came from



the southwest; and at the close, from the northwest; but in neither case from more than a few points to the north or south of the magnetic west. There were but two hours during the whole voyage during which the wind blew from any point east of south. At the extreme of violence for each gale the wind blew dead ahead. During the intervals of a few hours between the gales, the sky would clear, and the wind come quietly in from the west, until its shifting to the southwest gave the signal for the opening of the next blow.

The barometer fell rapidly and low at the beginning of each gale, and rose more slowly afterwards. If Captain Galton's hypothesis of a reversed descending cyclone to accompany a rising barometer after the direct ascending cyclone with a falling barometer, be intended to apply to all atmospheric disturbances, small as well as large, some exhibition of this supposed phenomenon should have been made by this series of gales. (Phil. Mag. No. 174, p. 225, Proceed. R. S., December 18th, 1862.) "It is hardly possible," he justly urges, "to conceive masses of air rotating in a retrograde sense in close proximity, as cyclonogists suppose, without an intermediate area of direct rotation, which would, to use a mechanical simile, be in gear with both of them, and make the movements of the entire system correlative and harmonious." But we have this very conception realized before our eyes, habitually, in every series of eddies on the surface of a stream. If the cyclonal columns were stationary and contiguous, some intermediate disturbance, analogous to a pinion between two cogs, must occur; and if the interval have a diameter equal to that of each cyclonal column, the disturbance might perhaps assume a simple reverse columnar form and motion at its circumference, opposed as they would be by the vertical stability of its axis. But if the two supposed stationary verticals were nearer than one diameter, the disturbances of the interval must become very complicated, and hardly recognizable on a chart by any simple system of curves.

But as, in fact, cyclonic columns, such as those under discussion, have a forward slip, like the eddies in water, the line of motion of any particle of one column (or of its observed base) is by no means in the curve of a volute; but, like the path described by a particle of the earth's surface in its course round the sun, approximates a straight line, oscillating from side to side without an epicycle. If, therefore, in a series of cyclones of retrograde projection, the intervals were filled with other cyclones of direct projection, there could be no concealing the fact; and at least traces of such an interval

system would have appeared in the log-book of the Canada, in the voyage under discussion.

Such a waved line crossing and recrossing the wake of the Canada, twelve times in eight days, would graphically represent the forward movement of the winds encountered. Theoretically, it would represent one of two things: either, 1st, a horizontal libration of the fronts of successive masses of condensed atmosphere moving magnetic east, or north of east; a supposition which I imagine no meteorologist would accept for a moment; or, 2d, a system of curves belonging to the southern sides of six small cyclones, following each other along a line not quite parallel to the course of the ship, and to the north of it, close to it at the western end, and diverging from it eastward.

I say *small* cyclones, because when we landed at Halifax the inhabitants spoke with delight of the lovely weather the people of Nova Scotia and Newfoundland had been enjoying for more than a fortnight. A glance at the map will show, therefore, the small radius to be ascribed to the gales through which we had been fighting slowly our way. We must consider it therefore probable that these gales, however vortical in build, belong to a different system of disturbances from the periodical storms of immense radial sweep which travel along the Atlantic coast inland in the same direction.

The next important point to be observed, is the fact of the sudden commencement of the system on the west, at longitude 45° west from Greenwich, that is, where the ship's course ran out of the Gulf Stream and approached the Banks. That we did not cut across the axis of the system, is plain, from the fact that no *southeast* or *northeast* winds were encountered. Otherwise it would be easy to consider this system of gales as attached by some law to the northern margin of the Gulf Stream, at least as to their common axis of forward movement. But unless the series of gales had exhausted itself precisely at the moment when we reached longitude 45°, or actually commenced at that longitude, it must be allowed that the Canada then and there sailed *under* the system; which, in that case, must be regarded as descending from some region to the southwest, and in the upper strata of the atmosphere, and impinging at that point upon the surface of the sea, thence, continuing forward, at that level, to the coast of Ireland.

Whether this be the best view or not, it is remarkable that these violent disturbances are popularly confined to one particular season of the year. Captain Moody, on consulting the record log-book of the

steamer, found that the next longest voyage of the Canada had been its first. He stated that all the voyages from Liverpool to New York, commencing about the 9th of January, were longer and stormier than the others. In 1863 the corresponding voyage made by the Europa had been one of 21 days. That of the America in 1862 had also been one of 21 days. The succeeding voyage is always considered a good one, not as against a prevalent west wind, but as against gales.

The *average* time of endurance of each gale was 26 hours, and the average interval of comparative calm was 6 hours. If 60 miles an hour were given as the speed of the wind, and this were considered to mark the speed of the vortical column, we would be obliged to consider the distance between the centres of the gales as about 2000 miles, and there could have been but one gale traversing at any one time the distance between the Banks and Ireland. There would be sufficient room, therefore, for it to assume any magnitude, however great. But the fair weather on the British provincial coast, as has been already said, seems to prove the small diameter of all the gales, and we must view each one, therefore, as making its solitary journey, as a simple eddy, nearly along the northern margin of the Gulf Stream, and probably enlarging its area as it advanced; which would account for the extreme violence of the gales we encountered last as compared with those encountered in the first part of the voyage.

But of course, the rate of motion of the nucleus cannot be fairly represented by the rate of motion of *any* given circle on its limb, unless that particular circle be selected at just the proper distance from the centre, to be a mean between the dead wind at the extreme circumference and the excessively rapid rotation at the centre. In some one of these gales, it is probable, that the ship's course did cut such a circle of mean motion, and got (without, of course, knowing it) the exact rate of the vortical, in the actual rate of the blast over the deck. It is a great mistake to draw a vortical storm with the shape which it would have if it had no body-movement forward and moved in vacuo. The fact must be, that most of the sections of a cyclone move forward with its nucleus in nearly parallel lines; and that the storm as a whole, while theoretically vortical, is in practice linear. It practises its gyrations only near its centre.

The form of such a gale, moreover, must be merely a form, like the form of a wave, the vortical movement being impressed on successive portions of air, which, after being in turn set moving, are in turn allowed to stop, fall into the rear, and come to rest.

Mr. H. S. Eaton remarks, in his paper on the antagonism of the polar and equatorial currents (Art. xli, Proc. B. Met. Soc., June, 1863), that "from some years' study of cyclonic storms and their courses Europewards, he should say that the greater proportion of these circular storms traverse the Atlantic in zones, parallel somewhat to the dotted line on his map of the great storm of the 18th and 19th of May, 1863, their course, however, varying according as the sun is north or south of the equator, their course being more *northerly* as the sun approaches the tropic of Cancer, and more southerly as it recedes therefrom." The line he draws, is one almost parallel to the course of the Canada after leaving the coast of Ireland, or about S. 20° W. (true). The coincidence of this course with that of the axis of the Gulf Stream after leaving the Banks, is a marked feature. No one yet, to my knowledge, has thoroughly discussed the action of the mass of air warmed, and no doubt also propelled in that direction, by the moving surface of the Gulf Stream, upon the wall of colder air to the north of it, and the vault of cold air overhead; yet we have in their apposition and reaction a cause of great and regular disturbance. Even if the mass of cold air to the north must be regarded as moving in the same direction, the different rates of the two movements, and the perpetual struggle of the lower part of the northern mass to inflow, and of the warm mass to uprise, must produce complicated movements of great regularity, and in the main vortical in a retrograde sense.

Admiral Fitzroy considers that he has established the occurrence of cyclones of destructive violence but limited area, originating locally in the vicinity of the British Islands. Are we then to look for such a spontaneous origination of vortical disturbances at any point along the track of our cyclones between America and Great Britain, or are they confined in their origin to the vicinity of land?

The principal points of interest, are the rate of the cyclones by which their relative distances might be measured, and the question of their generation about the 45th degree of west longitude, or their descent at that meridian from the upper regions of the atmosphere over the Atlantic seaboard States.

Pending nominations Nos. 508 to 521, and new nomination No. 522 were read.

Resolutions recommended by the Publication Committee, for the purchase of old copies of exhausted editions of the Transactions, old series, for the printing of No. 1, and title-

page of Vol. 1, of the Proceedings, and for providing a cover for future numbers of the Proceedings, were adopted.

On motion, Mr. Price, Mr. Fraley, and Mr. Colwell, were appointed a committee to take into consideration and report at the next meeting upon the subject of providing a lot for the future building of the Society.

And the Society was then adjourned.

Stated Meeting, April 15, 1864.

Present, fifteen members.

Dr. Wood, President, in the Chair.

Letters acknowledging the receipt of publications were received from the Natural History Society of Nuremberg, November 14th, and the Royal Society at Upsal, September 15th, 1863.

Letters of invoice were received from the Imperial Society of Naturalists at Moscow, September 6–12; the Royal Society at Upsal, October 15th; the Royal Society at Berlin, November 30th; the Royal Society at Stockholm, November 18th; the Royal Society at Munich, November 20th, 1863.

Donations for the Library were announced from the Royal Academies and Societies at Stockholm, Upsal, Moscow, Berlin, and Munich; the Geological Society at Berlin, the Natural History Society at Nuremberg, and the Zoological Society at Frankfort on the Maine; the Bureau of Public Instruction at Paris; MM. Desnoyers and Boucher de Perthes, Prof. Hennessy, Blanchard & Lea, and the Rev. Mr. Barnes, of Philadelphia.

Donation for the Album, from Mr. Isaac Lea, of the portrait of Dr. George Jager.

On motion, the Natural History Society of Nuremberg was placed on the list of correspondents to receive the Proceedings.